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NASA SCIENTISTS
REPORT ON AIRCRAFT
IMPROVEMENTS, SAFETY

Research accomplishments leading to significant improvements in the usefulness and safety of all types of aircraft were reported by National Aeronautics and Space Administration scientists to more than 400 technical experts from industry and government at a three-day NASA Conference on Aircraft Operating Problems which ended May 12.

The technical sessions, held at the Langley Research Center, Hampton, Va., under the sponsorship of NASA's Office of Advanced Research and Technology, (OART), included 34 papers presented by scientists from Ames Research Center, Moffett Field, Calif.; Flight Research Center, Edwards, Calif.; Langley; and the Federal Aviation Agency.

At the opening session, Charles J. Donlan, Associate Director of Langley, stressed the importance of the technical conference as a rapid, effective technique for transmitting the results of NASA research to the segments of the airframe and air transport industries where they can be most usefully applied.

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Dr. A. J. Eggers, Deputy Associate Administrator of OART, emphasized that operating problems research must be an essential ingredient in the maintenance of U.S. leadership in the design, development and useful employment of aircraft of all kinds.

General chairman of the Conference was Laurence K. Loftin, Jr., Assistant Director of Langley.

Session Chairmen for presentations on major groups of subjects were:

General Studies, Session I, Philip Donely, Chief, Flight Mechanics and Technology Division, Langley.

General Studies, Session II, George E. Cooper, Chief, Flight Operations Branch, Ames.

Subsonic Aircraft, William S. Aiken, Jr., Chief, Operations Research Branch, Aeronautics Division, OART.

Supersonic Aircraft, Thomas A. Toll, Associate Chief, Full-Scale Research Division, Langley.

General Aviation Aircraft, John P. Campbell, Associate Chief, Flight Mechanics and Technology Division, Langley.

V/STOL and STOL Aircraft, John P. Campbell.

(NOTE TO EDITORS -- BRIEFS AND HIGHLIGHTS OF THE TECHNICAL PAPERS ARE ATTACHED TO THIS RELEASE)

"Recent Studies of Runway Roughness," by Garland J. Morris and Albert W. Hall of Langley, reviewed NASA studies on the runway roughness problem, particularly in regard to the vibrations and motions to which the pilot of an airplane may be subjected and the attendant difficulties in reading his instruments and precisely controlling his airplane.

It was noted that the effects of a given runway surface condition can be markedly different with different airplanes. The pilot of one airplane may complain bitterly about the rough ride on the same runway that appears smooth in another plane. The speed of an airplane rolling over a runway can also have a large effect on the severity of the motions.

In tests of one large airplane it was found that severe pitching oscillations were induced by runway waves only one to two inches high with a wave length of about 100 feet.

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"Traction of Pneumatic Tires on Wet Runways," by Walter B. Horne and Upshur T. Joyner of Langley, covered some relatively new research on wet runway traction of airplane tires.

The results of a series of tests at Langley's Landing Loads Track to investigate the effects of varying runway surface texture on the attainable braking effect of tires on wet surfaces indicated a well defined relationship between the mean depth of the surface texture and the braking effect.

In an effort to alleviate the tendency of tires to hydroplane--they ride up on a film of water like a ski while running at high speeds in standing water, an investigation was made of air jets directed at the runway surface ahead of a tire. The jets effectively removed the standing water ahead of the tire and permitted it to develop up to 60 per cent of dry surface braking effort.

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"Summary of Atmospheric Turbulence Data," by Roy Steiner of Langley, contained information compiled from flight measurements in the past few years. The amount of data for both storm and non-storm turbulence, particularly at the higher altitudes, up to 75,000 feet, has been greatly increased in recent years, largely from U-2 flights.

Measurements have been made over Turkey and Japan as well as the United States to provide essentially world-wide coverage.

The results of the measurements in non-storm conditions indicate a given intensity of turbulence is encountered 10 times as frequently at 20,000 feet altitude as at altitudes of 50,000 feet.

The intensity of turbulence encountered in storm activity is about three times that for non-storm or clear air turbulence.

There appeared to be no need to revise the standards for gust velocities now in general use on the basis of this information.

"Preliminary Study of Steep Instrument Approach of Three Conventional Aircraft," by Albert W. Hall, Robert A. Champine, and Donald J. McGinley, Jr., of Langley, summarized an investigation aimed at defining the steepest instrument landing approach paths that might be operationally practicable in the interest of reducing airspace involvement in landing operations and the noise inflicted on an airport's neighbors.

Very limited tests with three airplanes flown by research pilots ranging from a trainer to a large jet transport indicated that a reasonable upper limit for instrument approaches was about six degrees angle of glide slope for all three planes, as compared to the three degrees presently used in instrument landing systems. Although the guidance equipment used for the tests was capable of guiding the airplane all the way to touchdown, the work load imposed on the pilot in precisely controlling the path of the airplane in two directions, with the limited information display provided, was too great to permit reliable all-the-way, or zero-zero landings. When his workload was reduced, by the copilot taking over lateral-directional control, the pilot was able, in some cases, to complete his landing on instruments.

"An Assessment of Titanium Alloy for Supersonic Transport Operations," by George J. Heimerl and Herbert F. Hardrath of Langley, was confined primarily to the titanium alloy Ti 8.1.1 (titanium alloy containing 8 per cent aluminum, 1 per cent molybdenum and 1 per cent vanadium.) Because of its generally good strength-to-weight ratio and high temperature properties, this alloy has emerged as a leading material candidate for the SST.

The properties of this material have been investigated in extensive tests which have included exposure to elevated temperatures up to 550° F. for as long as 24,000 hours. Most of the important properties such as tensile strength, fatigue strength, fatigue crack propagation and residual strength have not been adversely affected by heat exposure; the strength of spot welds was reduced about 15 per cent after 24,000 hours exposure at 550°.

The area of primary concern relative to the Ti 8.1.1 material is its susceptibility to salt stress corrosion at elevated temperatures. This problem has been a subject of much study, and it is not possible at the present time to predict whether or not this characteristic will impose any substantial restriction on the use of Ti 8.1.1 material in the SST.

"Deep Stall Aerodynamic Characteristics of T-tail Aircraft," by Robert T. Taylor and Edward J. Ray of Langley, showed some results of a wind-tunnel study of the deep stall. A typical T-tail airplane configuration with fuselage-mounted engine nacelles was used as the basic model on which variations in tail position and size, nacelle location and fuselage width, were investigated.

A severe pitching instability beyond the initial stall with the basic configuration was completely eliminated by mounting the horizontal tail low on the fuselage at the base of the vertical tail.

Repositioning the nacelles had a powerful effect on the instability in the stall which could be either favorable or unfavorable.

Increasing the span of the T-tail and reducing the width of the fuselage both tended to reduce the instability in the stall.

The authors pointed out that the susceptibility to deep stall problems with the T-tail configuration arises primarily from the tendency for the horizontal tail, in this position, to become immersed in the stalled wake of the wing and other airplane components at high angles of attack. The tail thereby loses its effectiveness as a stabilizing device.

"Simulator Studies of the Deep Stall," by Maurice D. White and George E. Cooper of Ames, discussed a piloted simulator study of the deep stall. A number of recent aircraft designs have incorporated T-tails--horizontal tails located at or near the top of the vertical tail--leading to renewed concern about the deep stall phenomenon which tends to be aggravated by this tail configuration.

The authors described the deep stall as the condition whereby at or beyond initial stall an airplane's angle of attack increased rapidly to very large values, by reason of pitching instability and rapid descent, arising from loss of lift and increased drag. In addition, the effectiveness of the elevator is greatly reduced in this condition. Depending on the particular airplane configuration, the airplane may become "locked" in the stall to the extent that recovery is extremely difficult or impossible.

Simulator flights into the deep stall were made with a number of pilots. It was found that the cues of attitude and airspeed used by pilots in recovery from normal stalls could be misleading in the deep stall to the extent that reliance on them could delay or prevent recovery. Angle-of-attack indication was proposed as a much

better cue for controlling the stall. Where the pilot is required to stall an aircraft, as in certain test flights, he should institute recovery procedures as soon as the stall condition becomes evident, to avoid deep penetration.

"Flight Tests Related to Jet Transport Upset and Turbulent Air Penetration," by William H. Andrews, Stanley P. Butchart, Thomas R. Sisk, and Donald L. Hughes of Flight Research Center, reported flight investigations of operating problems of subsonic jet transports. One problem area that has been of concern in recent years arises from incidents and accidents involving upsets of large jet transports in turbulence.

In the flight investigation of the problem, performed with the cooperation of the Federal Aviation Agency, and utilizing two FAA jet transports, first attention was given to discovering any characteristics of the airplane that might contribute to severe upsets or recovery difficulties. It was found, for example, that effectiveness of the elevators at high speeds was relatively low, and that out-of-tolerance elevator control tab seals and out-of-trim stabilizers reduce available elevator travel and increase control forces, all of which increase the difficulties of maintaining control or recovering from upsets in rough air. It was demonstrated that proper use of the stabilizers or spoilers provided effective means of recovery from upsets. Use of the yaw damper was found to substantially reduce the difficulties of flying in rough air.

"Simulator Investigations of the Problems of Flying a Swept-Wing Transport Aircraft in Heavy Turbulence," by Richard S. Bray and William E. Larsen of Ames, was a report on the introduction of the pertinent characteristics of a large jet transport into the Height Control Simulator at Ames. This device is capable of reproducing the vertical accelerations which a pilot would feel in actual flight in rough air. The tests, which involved a number of industry pilots, demonstrated that pilots, in some cases, did lose control of the airplane in severe turbulence. They also indicated that pilots developed increased tolerance to the rough air after some exposure, and improved their ability to maintain control, suggesting that training pilots in rough air simulators could be useful. One aspect of rough air response, that appeared particularly annoying to the pilots and caused difficulty in scanning instruments, was a 4-5 cycle per second vertical vibration in the cockpit. Some studies are under way to evaluate methods of attenuating this vibration.

"Prediction of Airplane Sonic Boom Pressure Fields," by Harry W. Carlson, Francis E. McLean, and Wilbur D. Middleton of Langley, concerned recent studies which indicate that the sonic boom problem of the supersonic transport may be somewhat less severe than has been anticipated.

An airplane at supersonic speeds produces a series of shock waves emanating from its various components which ultimately coalesce into the familiar N-shaped pressure wave often heard on the ground as a sharp double bang. Recent theoretical work supported by wind-tunnel and flight measurements indicates that with very large aircraft such as the supersonic transport, particularly in the lower altitude phases of supersonic flight such as climb-out, the coalescence of the shock waves may not be completed by the time they reach the ground with the result that the intensity of the boom -- the so-called overpressure -- is reduced.

It may be possible to take advantage of this effect and achieve reductions in sonic boom overpressure by suitable design of the airplane configuration.

"Implications of the Effects of Surface Temperature and Imperfections on Supersonic Transport Operations," by John B. Peterson and Albert L. Braslow of Langley reveals two factors which can have important effects on the drag of the SST--surface temperature and surface imperfections.

Reduction of the skin temperature of a supersonic transport in cruising flight by radiation of heat away from the surface can cause a significant increase in drag, indicating that, in cases where the temperature might not be of primary concern, keeping the skin emmissivity low in the interest of reduced drag could be of substantial benefit in the operation of the SST.

Research shows that surface imperfections such as waves, stepped joints, and roughness have a considerably greater effect on drag at supersonic speeds than at subsonic. It is estimated that the effects of the overall surface irregularities that might be present on a supersonic transport if present construction tolerances were used could represent almost 4 percent of the smooth surface drag. Since a 1 percent increase in drag can reduce the payload of the SST by 1,000 pounds, this could be a significant design and maintenance factor.

"Consideration of Fuel Requirements for Supersonic Transport Operation," by J. W. Stickle of Langley, treated the supersonic transport fuel requirements in relation to the variable operational and environmental factors that the aircraft will encounter.

The paper described factors such as wind, temperature, altitude assignment and passenger load factor, which would be considered in the flight plan and accounted for in loading fuel on the airplane. By a statistical analysis of the effects of these factors, for a design range of 3160 nautical miles (New York to Paris), the author determined the probabilities that given amounts of fuel, in addition to the basic design mission fuel, would be required to complete the mission. He found, for example, that in order to accommodate the demand for seats on 99 out of 100 flights in the summer season, the aircraft design range would have to be 400 nautical miles greater than the actual trip distance.

Variations in performance between aircraft, uncertainties in weather prediction, and air-traffic control, which cannot be accounted for in flight planning, were treated statistically in an effort to arrive at a rational basis for determining design fuel reserve allowances. The results indicated that to achieve the same level of protection as present fuel reserve requirements for subsonic jet transports

(excluding allowances for diversion to alternate destination), it would be necessary to provide reserve fuel of 13 to 14 per cent of basic mission fuel for the New York to Paris flight.

"VTOL Aircraft Operation in the Terminal Area," by John P. Reeder of Langley, discussed a number of considerations relative to operations of V/STOL aircraft in the terminal area.

He emphasized that to realize potential advantages of V/STOL aircraft for safer operations in bad weather, and for safer operations in bad weather, and for more effective use of available airspace in congested terminal areas, full use must be made of their low speed capabilities. To do this would probably require separate routing and air traffic control of V/STOL and conventional aircraft in the terminal area. He suggested the possibility that this separation could be accomplished by routing V/STOL traffic under the conventional traffic.

The reduction in airspace use with the V/STOL aircraft was illustrated by comparing a typical landing approach pattern with that of a conventional airplane: the distances involved were shown to be reduced by about one-half. However, the time required to execute the landing approach pattern under instrument flight conditions - about 5 minutes - estimated on the basis of present experience, was considered too long to be acceptable in view of the high fuel consumption rate in such low-speed operations. The speaker discussed several piloting problems of low speed flight that can increase the landing approach time requirements, including complex conversion procedures, poor or marginal handling qualities,

and wind effects. He indicated that every effort must be made in design of operational aircraft to achieve adequate handling characteristics, and simple conversion, and that improved pilot information displays will be required.

"Operational Experiences of General Aviation Aircraft," by Joseph W. Jewel, Jr. and Walter G. Walker of Langley, described a program which has recently been inaugurated to obtain statistical information on the operational practices and loads experience of Aircraft in the General Aviation Category aircraft.

The program will involve 64 aircraft both single- and twin-engine, ranging in weight from 1500 to 20,000 pounds. The types of operations in which the planes are being used are executive transport, instructional, commercial survey and personal.

Special instrumentation is being installed in the airplanes from which it is expected that information on operating speeds and altitudes, and gust, maneuvering and landing loads for about 64,000 flight hours will be obtained.

The very limited amount of data that have been gathered, thus far, in the various classes of operations indicates that, in general, the aircraft are being operated within design limits.

"The Effect of Yaw Coupling in Turning Maneuvers of Large Transport Aircraft," by Walter E. McNeill and Robert C. Innis of Ames relates to a study of low-speed handling qualities requirements of very large airplanes such as the supersonic transport.

The study involved tests in a 5-degree-of-freedom piloted simulator adjusted to reproduce the motions a pilot would feel in turning maneuvers, which have an important effect on the handling qualities of a supersonic transport. Varying degrees of yawing response to turning maneuvers were simulated with a number of pilots, the results indicating that the basic requirement is a response which keeps sideslipping tendency in turns to a minimun so that little or no rudder application is required.

Comparison of the simulator results with corresponding tests in flight on a subsonic jet transport indicated that the pilot's relatively great distance from the airplane center of gravity in the SST may make him more sensitive to and less tolerant of the sideslip involved in turns.

"Operating Problems Peculiar to V/STOL and STOL Aircraft," by John P. Campbell of Langley, outlined some of the potential operating problems associated with the achievement of very-low flight speeds by vertical/short takeoff and landing (V/STOL) and STOL aircraft.

He noted that hovering and very low-speed capabilities lead to requirements and problems not encountered with other aircraft, including high installed power, powerful downwash effects from propellers or jets, the need for configuration conversion between hovering and cruising flight and vanishing aerodynamic stability and control.

One of the consequences of high power requirement for hovering is the associated high fuel consumption, particularly with jet V/STOL aircraft. This precludes long hovering operations.

The conversion procedures required for several V/STOL types were compared, and it was noted that some of the more complex aircraft designs, would serve to substantially increase the pilot's work-load. He pointed out that high noise levels with the V/STOL aircraft can be expected as a consequence of the high power requirement.

Campbell showed that higher approach and climb angle capability of the V/STOL tends to compensate, however, for higher source noise and to limit the disturbance to a smaller area on the ground relative to conventional airplanes. On the other hand, for small, close-in airports the noise may still be a problem.

"Airplane Spinning," by James S. Bowman of Langley discussed several aspects of airplane spinning, which is a problem of particular concern for some classes of General Aviation airplanes.

The way in which the mass of an airplane is distributed along the fuselage and wings was indicated to be a major factor in determining the manner in which an airplane spins and the control procedure which the pilot should use for recovery from the spin.

For example, with the mass distributed largely along the fuselage, aileron action with the spin and rudder against the spin is normally the effective recovery procedure, whereas with mass concentrated along the wing, elevators down and rudder against the spin should be used.

Design of the vertical tail so that at least a substantial part of the rudder is not blanketed by the wake of the horizontal tail or some other component has been found essential to achievement of acceptable spinning and recovery characteristics.

It was noted that for a moderate range of airplane mass characteristics, tail design requirements for good spin recovery can be predicted from available spin test results, but that for extreme cases, special spin tests are still required.

"Low-Speed Flight Characteristics of a Powered-Lift Jet Transport During Landing Approach," by Robert O. Schade and Harold L. Crane of Langley, described the landing approach characteristics of a large jet transport type airplane equipped with a high-lift system.

In this aircraft, the high lift obtained by blowing high velocity air from the engine compressors over a specially designed flap allowed a reduction in operational approach speed to 90 knots from the 120 knots value for the basic airplane.

The minimum safe approach speed was determined to be about 20 percent in excess of the power-on stall speed. Instrument landing conditions down to a height of 200 feet were simulated and it was found that the landing approach and touchdown, with the stability augmentation system employed, could be performed in the high-lift, slow speed condition with at least as good accuracy as with the basic airplane.

Two characteristics of the aircraft in the high-lift condition which were considered undesirable were a nosedown attitude in landing such that the nose-wheel tended to touchdown first, and a marked nose-down trim change near the ground. In general, however, the handling characteristics of the airplane were not greatly different from those of conventional jet transport aircraft.

"Some Performance and Handling Qualities Considerations for Operation of STOL Aircraft," by Seth B. Anderson, Hervey C. Quigley, and Robert C. Innis of Ames, presented the findings of NASA flight research with several large Short Takeoff and Landing (STOL) aircraft.

Usually these aircraft use some of the engine power to augment the wing lift rather than to utilize the power directly for lifting as in V/STOL aircraft, and it was found that a lifting capability of about three times that of conventional aircraft could be achieved to effect the slow speed operation needed.

It was noted, however, that with this type aircraft the landing glide slope that can be utilized at the slow speeds desired tends to be relatively flat--possibly not much more than the conventional 3 degrees--because of the need for relatively high power to maintain high lift.

In slow speed piloting problems, lateral-directional control was indicated to be the most troublesome. Characteristically, yawing in the wrong direction in turns increased the tendency to sideslip, requiring the use of the rudder which in the face of the slow responses at low speeds, was difficult. These characteristics will probably require the use of suitable stability augmentation systems in STOL aircraft to achieve adequate handling characteristics.

"Operational Experiences with the X-14A Deflected Jet Aircraft," by L. Stewart Rolls of Ames, cited several operational problems encountered in the course of flight research investigations with the experimental X-14A VTOL aircraft.

This airplane incorporates a fuselage-mounted jet engine system using the vectored thrust principle to provide either lift or forward propulsion. One of the problems cited was that of reingestion of hot exhaust gases by the engine, which occurred when the aircraft was headed into a moderate wind. Result was a severe reduction in available thrust.

It was also found that the airplane suffered a "suck down" force near the ground of as much as 12 per cent of the weight by reason of the pressure field created by ground interference with the exhaust flow.

Ground erosion effects due to the high velocity exhaust were examined at some length. Some of the effects noted included the formation of large dust clouds with the airplane flying as high as 45 feet, the lifting of large pieces of poorly anchored sod with the airplane at a height of 6 feet, and some surface flaking and erosion in operations on concrete surfaces, particularly when wet. Tests of the aircraft from a formed-in-place fiber-glass mat indicated that it had considerable promise as an erosion resistant surface.

Another problem revealed by operations of this airplane was the disorientation of the pilot during hovering flight, in the absence of

adequate visual references and motion cues. Major piloting difficulties were occasioned both in daylight flights at 2500 feet and in night flights near the ground, pointing up the need for better pilot-information displays for poor-visibility hovering operations.

"Ground Effects on V/STOL and STOL Aircraft," by Richard E. Kuhn of Langley, points out that one of the operating problem areas essentially unique to V/STOL and, to some extent, STOL aircraft arises from the effects of interference of the ground with downward directed propeller slipstreams and jet exhausts.

The author summarized the results of several investigations of these ground effects, including considerations of both the effects on the ground surface and on the aircraft itself. He showed that the character of the flow of the slipstream or jet exhaust impinging on the ground varies widely, depending on the aircraft configuration.

With a slipstream discharged from the center of the airplane the flow simply spreads out along the ground in all directions, whereas, with symmetrically disposed multiple slipstreams the flow meets in the center, rises and impinges on the lower part of the aircraft.

This latter condition can give rise to unsteady motions of the aircraft as it rises from or settles to the ground. In the case of a center-located jet the hot gases spreading along the ground can be turned back by wind and reingested by the engine with a resultant loss of power.

In regard to surface erosion, tests were made with materials such as might be found on unprepared runway surfaces. It was indicated that loose sand and dirt can be eroded by any type of V/STOL slipstream, including the helicopter. Crushed rock can be dislodged by propeller-type V/STOL aircraft but a good sod surface will be eroded only by the high velocity exhaust of a jet engine. For paved surfaces it was shown that asphalt types would be readily damaged by the high temperature of jet

exhausts, and that these temperatures may be sufficient to damage some types of concrete. It was pointed out in conclusion that the ground effects discussed are of significance only for a range of heights up to 20 or 25 feet and at speeds below 40 knots.

"Review of the XB-70 Flight Program," by Thomas R. Sisk, Kirk S. Irwin, and James M. McKay of the Flight Research Center, is a report on a cooperative Air Force and NASA effort to study B-70 flight characteristics, particularly where the findings might have application to other supersonic cruise airplanes such as the SST. Although both B-70 airplanes are to be used in the investigation, the major portion of the quantitative information will be obtained with the No. 2 aircraft which has not yet flown. The investigations will include measurements of flight control characteristics, performance capabilities, structural loads, and environmental factors throughout the flight envelope of the aircraft from low-speed, low altitude (takeoff and landing), to high altitude cruise at supersonic speeds.

The quantitative measurements are obtained with NASA instrumentation installed in the aircraft and on the ground.

Preliminary low-speed handling characteristics obtained from the first aircraft appear satisfactory even without stability augmentation, except that rolling response to control movements was somewhat greater than desirable. In the flight condition near the speed of sound it was found that greater deflection of the movable wing tips, than expected, would be needed to improve directional stability, and that more longitudinal control was required for trim than had been anticipated.

At supersonic speeds, handling characteristics were considered satisfactory with the stability augmentation provided.

In general, the aircraft has performed well, and appears to offer good potential as a research vehicle.

"Some Factors Affecting Fatigue of Aircraft Structures," by Herbert F. Hardrath of Langley, noted a number of facets of fatigue to emphasize the nature of the problem. For example, it was shown that for various alloys of a metal such as aluminum or steel with different strength ratings, the weaker alloys are likely to develop fatigue cracks more slowly and maintain greater residual strength with larger cracks than the stronger ones. (To emphasize the need for careful inspection and maintenance procedures, it was noted that a relatively minor tool mark in a highly stressed part can initiate a crack and cause an early failure.) It was pointed out that the once-per-flight cycle of lifting the entire weight of the aircraft and returning it to the ground - the ground-air-ground cycle - contributes much more to fatigue than gusts or any other loading conditions and that, therefore, number of flights is more significant than hours of flight in establishing inspection schedules.

"<u>Introduction to Supersonic Transport on the Air Traffic Control Study Program</u>," by Thomas A. Toll of Langley, revealed the objectives and scope of the cooperative program of the NASA and Federal Aviation Agency for investigating the mutual interactions of the supersonic transport and the air traffic control system.

The program involves the Air Traffic Control Simulator facility of the FAA at Atlantic City and the specially designed Supersonic Transport Simulator at the Langley Research Center, functioning together by means of a telephone cable link. He cited the objectives of the program: 1. To determine what effects the introduction of supersonic transport operations might have on the workings of the air traffic control system; and 2. To study the effects of air traffic control constraints on operating procedures of the supersonic transport as a design factor. Both aspects of the program were discussed in the two papers.

"<u>Effects of the Supersonic Transport on the Air Traffic Control System</u>," by Joseph O'Brien and Andrew L. Sluka of FAA, described the ATC center and some of the initial results of the program.

The ATC simulator provides a realistic representation of a heavy traffic situation in the New York area which includes 11 simulated supersonic transport targets in addition to the Langley supersonic transport simulator. Experienced controllers direct the pilots of the Langley simulator by telephone line and the position of the simulated SST is transmitted back to the controller's displays.

In the investigation to date, priority and no-priority treatments of the supersonic transports relative to subsonic traffic have been studied and it was found that priority treatment increased delays to subsonic traffic as much as 13 per cent. The total number of aircraft per hour that could be handled was reduced by about 10 per cent when priority was used. It was concluded that with limited priority for the SST, the operation of the air traffic control system would not be unduly affected.

"Effects of the Air Traffic Control on the Supersonic Transport," by Norman S. Silsby, Milton D. McLaughlin, and Michael C. Fischer of Langley, described the Supersonic Transport Simulator and discussed some of the early results of operations in the air traffic control environment.

The SST simulator is of fixed-base type incorporating a complete large transport flight deck with all the presently used navigation and communications equipment, flight instruments and controls. It operates in conjunction with a large computer complex which processes

the pilot's control inputs and provides the proper reactions of flight instruments and navigation equipment to represent the response characteristics of the aircraft simulated.

Two supersonic transport configurations have been simulated in the program to date, and several experienced commercial airline crews have been utilized. One problem revealed by the investigation was that of following presently established arrival and departure routes involving turns. Because of its high speed and large turning radius the SST would overshoot the desired track beyond the turn when using normal procedures.

It appeared that a procedure involving lead turns might be required to avoid excessive use of airspace. It was also found that the pilots' communications and navigation workload was considerably increased relative to that of subsonic aircraft in the early stages of approach to the terminal area because of the greater frequency of operations associated with the higher speed. Increases of flight time and fuel usage of as much as 4 minutes and 5 per cent in trans-Atlantic departures and 10 minutes and 3-4 per cent in trans-Atlantic arrival were observed to result from air traffic control maneuvers.

"Simulator Evaluation of a Display for Zero-Zero, Manual Landings," by Joseph G. Douvillier, Jr., of Ames, described an all-weather instrument landing information display system being studied by means of tests in the Ames Transport Simulator.

The display consists of a symbolic representation of the runway, as it would appear to the pilot if he could see it, projected on the windshield together with a line representing the horizon. Other items of information, such as the point of intersection of the flight path with the ground plane, and an altitude indicating line, were added to the display and evaluated. With some learning, pilots were able to complete landings, using the display, with about the same accuracy as when visual conditions were simulated.

The display system is being installed in a research airplane for evaluation in flight.

"<u>Factors Relating to Airport-Community Noise Problem</u>," by Harvey H. Hubbard, Jimmy M. Cawthorn, and W. Latham Copeland of Langley, dealt with aircraft noise, factors relating to the noise level imposed on the community by aircraft operations, and with community reaction. Since human sensitivity is the basic factor in the noise problem, considerable attention has been directed to subjective reaction studies.

Two noise properties found to increase the annoyance potential of a given physical noise level are the presence of pure tones, such as jet engine compressor whine, and increased duration of the noise. Reduction of the noise at its source is another area of investigation.

Among the means cited for achieving major reductions in source noise were increasing the by-pass ratios of turbo-fan engines to substantially greater values than presently used, and suppressing compressor whine by such devices as inlet resonators, suitable spacing of compressor stators and rotors, and checking the inlet air flow. Studies of compatible land use is planned as future work. It was noted also that adoption of different operating procedures for aircraft might provide some alleviation of the community noise problem.

"Preliminary Measurements of Takeoff and Landing Noise From a New Instrumented Range," by Carole S. Tanner and Norman J. McLeod of the NASA Flight Research Center, described a new aircraft noise-research range at Edwards, California, which is expected to provide an accurate range for future studies of noise problems with operational aircraft.

The new facility consists of an array of 12 microphones installed at intervals along both sides of the runway and beyond the runway for a total distance of 25,000 feet and connected by cables to a van fitted with specially developed equipment for accurately measuring and analyzing the noise levels at each microphone station. Preliminary measurements in takeoffs of the XB-70 airplane and a jet transport have pointed up some apparent inadequacies in noise prediction procedures which this new facility should ultimately help to resolve.

"<u>Operational Experiences of Turbine-Powered Commercial Transport Airplanes</u>," by Paul A. Hunter and Walter G. Walker of Langley, was a summary of NASA's program of statistical measurements of the operational environment of turbine-powered transport airplanes. Special instrumentation (VGH and VG recorders) installed in 46 jet transports and 19 turbo-prop transports, operated by major United States and European airlines, have been gathering information on operating practices and air loads in routine scheduled operations for several years.

The information from this program provides transport operators and designers with continuous up-to-date information on the actual operational environment of the aircraft in relation to design limits. For example, it was noted early in the program that turbine-powered transports were frequently exceeding design air-speed limits. Changes in the limits and warning devices were instituted and largely eliminated the overspeed incidents. Statistics on the frequencies of flight loads encountered by these aircraft were cited and were shown to be generally similar to the loads experiences of earlier types.

"A Simulator Study of Take-Off Characteristics of a Proposed Supersonic Transport Aircraft," by Charles T. Jackson, Jr. and C. Thomas Snyder of Ames, detailed research in a facility with a completely equipped pilot's station and a television projected view of a runway through the windshield. Tests so far have included the simulation of a delta-winged supersonic transport as well as a subsonic jet transport as a basis of comparison.

Among the findings of the study it was noted that 3 to 4 seconds were required to properly execute rotation of the supersonic aircraft to lift-off attitude, which involved starting rotation some 24 knots below desired lift-off speed.

The take-off performance of supersonic transport was found to be considerably more sensitive to variations in the angle of rotation at lift-off than the subsonic aircraft. The take-off performance was nevertheless considered good. Further tests are planned with a variable-sweep supersonic transport simulation.

"Use of Weak Radiation Sources to Determine Aircraft Runway Position," by Fred J. Drinkwater III and Bernard R. Kibort of Ames, cited a new device with a potential for increasing safety in the takeoff of heavily loaded airplanes.

The equipment consists basically of very weak radioactive sources imbedded in the runway surface at known intervals along its length, with relatively simple radiation detection, modulation and readout equipment installed in the airplane. With this device the pilot is continually informed of his position along the runway under any visibility conditions and, by correlating this information with his airspeed, can determine whether his takeoff is proceeding satisfactorily, or, in event of engine failure, whether he is past the critical decision point for aborting the takeoff.

The radiation effects and potential hazards were evaluated but further work will be required to insure compatibility with airport operating practices and maintenance crews.

"Significance of the Atmosphere and Aircraft Operations on Sonic Boom Exposures," by Domenic J. Maglieri and David A. Hilton of Langley, analyzed the results of an extensive series of sonic boom tests in relation to several operational and environmental factors.

The paper discussed the "super-boom" phenomenon, whereby the pressure waves produced at various points along the flight path come together or focus at a point on the ground, creating a much higher overpressure than would be obtained were the aircraft not accelerating at supersonic speed.

The location of the super-boom which occurs only in a limited region could be estimated theoretically to within about 5 miles, but the magnitude of the overpressure, measured to be as much as double the normal value, could not be adequately predicted.

Ordinary atmospheric disturbances have major effects on the magnitude of the overpressure in the sonic boom and the shape of the pressure wave.

The character of the sonic boom stimulus to an observer inside a building is different from that outside. Within a building the observer hears sound produced by the response of the building to the sonic boom and is therefore conditioned by the vibration characteristics of the building.